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Ice core age dating and paleothermometer calibration based on isotope and temperature profiles from deep boreholes at Vostok Station (East Antarctica)

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Abstract

An interpretation of the deuterium profile measured along the Vostok (East ANtarctica) ice core down to 2755 m has been attempted on the basis of the borehole temperature analysis. An inverse problem is solved to infer a local 'geophysical metronome,' the orbital signal in the surface temperature oscillations expressed as a sum of harmonics of Milankovich periods. By correlating the smoothed isotopic temperature record to the metronome, a chronostratigraphy of the Vostok ice core is derived with an accuracy of ±3.0-4.5 kyr. The developed timescale predicts an age of 241 kyr at a depth of 2760 m. The ratio δD/δTi between deuterium content and cloud temperature fluctuations (at the top of the inversion layer) is examined by fitting simulated and measured borehole temperature profiles. The conventional estimate of the deuterium-temperature slope corresponding to the present-day spatial ratio (9 per mil/°C) is confirmed in general. However, the mismatch between modeled and easured borehole temperatures decreases noticeably if we allow surface temperature, responsible for the thermal state of the ice sheet, to undergo more intensive precession oscillations than those of the inversion temperature traced by isotope record. With this assumption, we obtain the long-term temporal deuterium-temperature slope to be 5.8-6.5 per il/°C which implies that the glacial-interglacial temperature increase over central Antarctica was about 15°C in the surface temperature and 10°C in the inversion temperature. Past variations of the accumulation rate and the corresponding changes in the ice-sheet surface elevation are simultaneously simulated.